N 74-28122

# ASPECTS OF CHECKING INSTALLATIONS FOR THE NOISE LEVEL OF ELECTRONIC EQUIPMENT

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One of the parameters that define the quality of electrical /381
engineering equipment and its manufacturing technology is the level of the noises generated in running.

The problem of noise level reduction has recently acquired particular importance in the context of measures to reduce pollution.

Of especial interest are electrical machines and transformers, for which the latest standards stipulate obligatory tests and noise level measurements, and that these be conducted separately for each product.

Electrical machine noises are caused by the running of moving parts (bearings, grippers, shaft vibration, etc.), as well as by vibrations of the machine's magnetic circuits.

In transformers, noises are caused especially by the upper harmonics of the electrodynamic forces in the sheets as well as in the winding. Moreover, the transformer tank makes its own contribution to the noise level as well to the noise frequency spectrum.

Another category of electrical engineering products, such as horns, bells and other sound alarm devices, require that the fre- /382
quency spectrum as well as the level of the sound generated be ensured.

Radio and TV receivers also must be checked in soundproofed enclosures in order to be able to determine the volume and spectrum of the sounds emitted.

A special role in diversifying and improving electrical engineering products is played by the methods and devices used for noise level measurement in order to furnish the necessary elements for introducing corrections into designs and manufacturing technologies.

The enclosures in which noise is measured must, in principle, meet the following conditions:

-- damp outer noises down to a level where they will not interfere with measurements;

-- eliminate reflections from the interior in order to make it possible to measure progressive acoustic waves.

The basic idea behind fitting out such an enclosure is for the measurements to be conducted in a free field.

In practice, however, the conditions of a free field cannot always be realized, and measurements in reverberating and semi-reverberating acoustic fields are also accepted.

In fitting out the enclosures for measurement of electric machine noise two extremes are to be encountered: in some cases the enclosure is equipped for complete soundproofing and total elimination of reflections while in other cases a completely unequipped enclosure is employed.

The conditions imposed on enclosures in which electric machine and transformer noise is measured, as well as the manner in which the room's performance is determined, depend directly on the desired accuracy and the nature of the measurements. /383

Measurements for the defectoscopy of electric machines by noise analysis must be conducted in a free field, i.e., the following relation must be satisfied:

$$I_2 = I_1 \left(\frac{r_1}{r_2}\right)^2 \qquad (1)$$

where $I_1$ is the acoustic intensity at distance $r_1$ from the source and $I_2$ is the acoustic intensity at the distance $r_2$ from the source.

Between acoustic intensity levels $L_1$ and $L_2$ there must exist the relation

$$L_2 = L_1 + 20 \log \frac{r_1}{r_2} \qquad (2)$$

The ideal free field consists of a perfectly quiet enclosure in which the equipment whose noise is being measured is suspended at a considerable distance from the ground.

Inasmuch as the ideal field cannot be realized in practice, enclosures are employed in which the conditions are as close as possible to the ideal.

In order to conduct measurements it is necessary to know the rules for totaling acoustic levels by totaling background noise and reflected waves with the noise generated by the equipment at the measurement site.

Thus, during the running of a piece of equipment or a machine, /384 the resultant noise level is given by the relation

$$(M_3) \quad L = L_1 + \Delta L$$

where $L_1$ is the machine noise plus the background noise of the enclosure; $\Delta L$ is determined from the curve of Fig. 1 as a function of $L_1 - L_0$ where $L_0$ is the background noise of the enclosure.

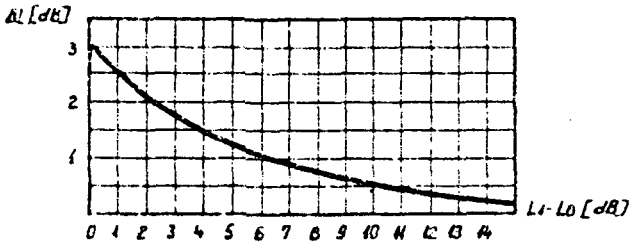


Fig. 1. $\Delta L = f(L_1 - L_0)$ when $L_1 \geqslant L_0$.

It can be seen from Fig. 1 that for $L_1 - L_0 \geqslant 10$ dB, $\Delta L < 0.5$, remaining practically constant. It follows that the level of background noise throughout the spectrum must be kept lower by 10 dB than the level of the noise generated by the running machine.

In the case of less accurate measurements, a difference between $L_1$ and $L_0$ smaller than 10 dB is also assumed, but the minimum value is limited to 4 dB on condition that some corrections /385 are made by judiciously placing the microphone near the machine for the purpose of reducing the enclosure's background noise $L_1 - L_0$. It follows from Eqs. $(M_2)$ and $(M_3)$ that an acoustically reflecting obstacle placed in a free field near the measurement site does not interfere with measurements so long as the path traversed by the incident and reflected wave is greater than double the distance between machine and microphone. It follows from Eq. $(M_2)$ that doubling the distance between machine and microphone leads to a reduction in the noise level at the measurement site by 1 dB.

Under the above conditions the reflected wave does not affect the total noise level; measurements can, therefore, be conducted with sufficient accuracy.

The distance between microphone and noise source depends on:

-- the size of the anechoic chamber;

-- the level of the background noise;

-- the size and shape of the noise source;

-- the acoustic field generated by the source.

Taking into account the fact that the distance between the microphone and the walls of the enclosure must be greater than a

quarter of the longest acoustic wave length of interest, the distance between source and microphone is limited in what follows to the size of the anechoic chamber.

On the hypothesis of a high level of background noise the microphone-source distance can be so reduced that the predominant noise at the measurement site will be that generated by the machine. There is, however, the danger that in the event of placing the microphone too close to the machine local values of a nonuniform acoustic field will be measured, which will lead to a deformed picture of the acoustic field.

As a result of the foregoing, in the case of small and /386
medium-sized machines and transformers the distance between microphone and noise source must be on the same order of magnitude as the greatest size dimension of the machine or transformer, but at least 0.3 m.

In the case of larger machines and apparatus the distance between microphone and source must be greater than the longest wavelength corresponding to the lowest frequencies of interest.

We have classified the above desiderata in terms of equipment size.

Studies we conducted led to four different solutions for noise measurement, namely:

1. 5 x 5 m anechoic chambers with free inner dimensions of about 3.2 m in which to measure the noise generated by small sources, such as automobile equipment, acoustic signalling apparatus, etc. (Fig. 2).

2. 6 x 6 m anechoic chambers with free dimensions of about 4.5 x 4.5 m, intended for measuring the noise of small and medium-sized electric motors (1-2 MW) (Figs. 3 and 4).

Anechoic chambers intended for measuring the noise generated by higher powered motors and electric transformers of up to 1.6 MVA, inclusively.

3. In this case the free dimensions of the enclosure must be about 12 m, and the total dimensions must be about 14-15 m.

4. In measuring the noise generated by high-power transformers, /389
motors and generators it no longer makes any economical sense to build anechoic chambers, so that we must resort to improvisations in assemblying sheds and noise measurements must be conducted at periods during which the production process of the sheds is interrupted.

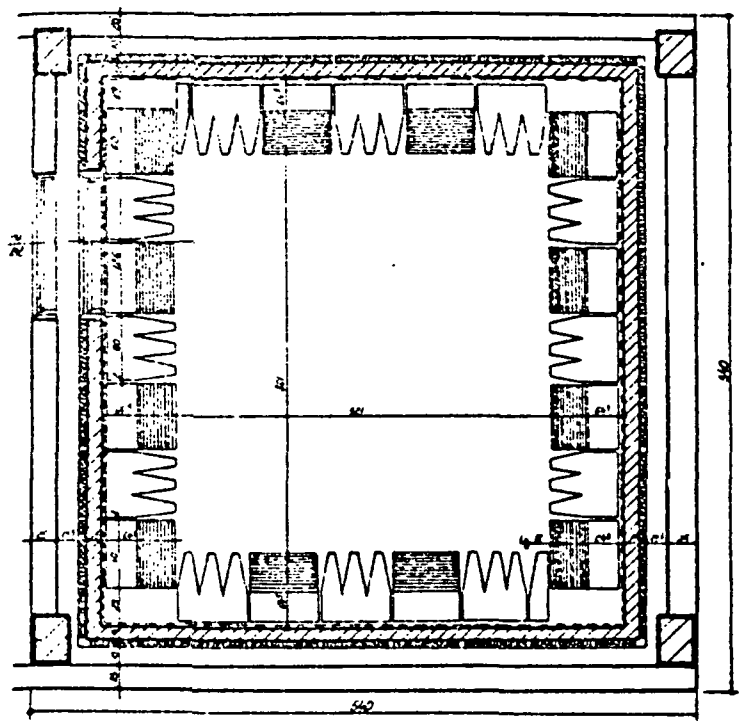

Fig. 2.

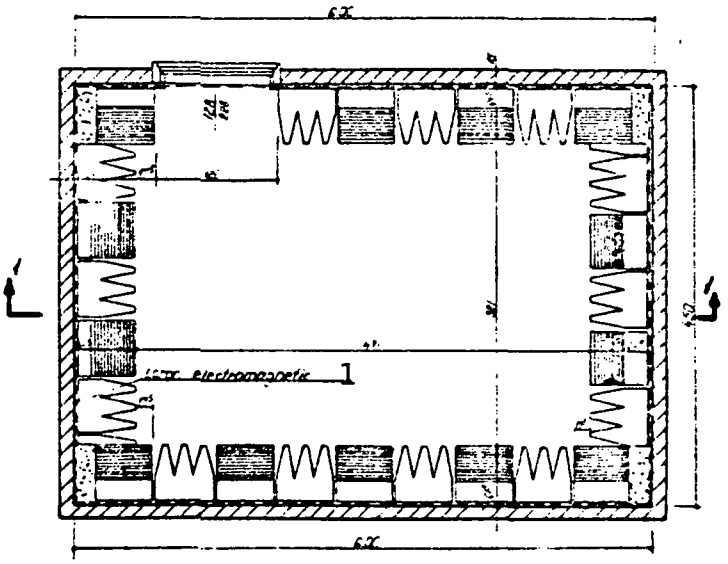


Fig. 3. Height plane ±0.00.
1. Electromagnetic screen.

All the anechoic chambers of the engineering industry are equipped with electromagnetic screens for the purpose of damping electromagnetic fields of about 60 dB within the 4-5 MHz frequency range.

It goes without saying that electric power is supplied to receivers mounted in screened anechoic chambers by means of filters so as to prevent perturbing waves from penetrating by way of the feed lines.

In the anechoic chambers mentioned in paragraph 1, the noise sources are suspended and the operating personnel circulates on nets placed above the floor of the enclosure.

In the anechoic chambers mentioned in paragraph 2, the equipment to be studied can no longer be suspended because of its great size and weight; in these cases the source fastening plate is so dimensioned that its proper vibration frequency will differ by one order of magnitude from that of the equipment to be studied.

Placing nets in small anechoic chambers constitutes a special problem, and in the event that this net is metallic it must be treated in a suitable manner with a view to avoiding perturbances of the electromagnetic field from the outside of the room toward the field of the net.

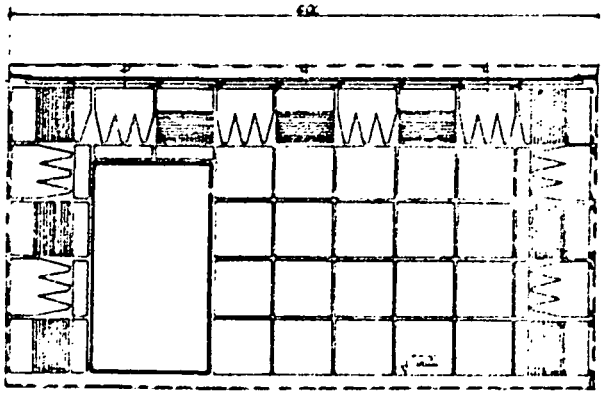

Fig. 4. Section 1.1.

The anechoic chambers described in paragraph 2 are suspended on springs, which prevents external vibrations from being transmitted to the inside of the room. In the case of larger anechoic chambers this solution becomes contraindicated from the economical point of view. The chamber will be placed at great distances from the vibration sources in quiet areas of the industrial shed. /390

In building anechoic chambers we used exclusively indigenous materials which gave complete satisfaction from the point of view of performance as well as behavior in time.

In the anechoic chamber of Fig. 2, the background noise has a value of about 25 dB, and in that of Fig. 3 the background noise is about 20 dB, both in the 2 kHz acoustic frequency range.


Summary

The level of noise generated by electrical engineering equipment constitutes one of the principal parameters that define the quality of the product. /392

As the general designer for electrical engineering and electronic plants, Electrouzinproiect in pursuit of improving the quality of products accorded particular attention to the checking installations for the noise level of electrical engineering products.

The paper describes some installations built by Electrouzinproiect for technological noise level checking installations.

Also given are some general considerations about the constructional elements and parameters of these installations.

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